DESCRIPTION

DATA PROCESSING APPARATUS AND METHOD AND ENCODING DEVICE OF SAME

TECHNICAL FIELD

[0001]   The present invention relates to a data processing apparatus able to suitably determine a quantization scale and a method and an encoding device of the same.

BACKGROUND ART

[0002]   In recent years, apparatuses have been developed based on the MPEG (Moving Picture Experts Group), JVT (Joint Video Team), or other standards which handle image data and, for the purpose of transmitting and storing information having a high efficiency, utilize the redundancy unique to image information so as to compress the data by application of a discrete cosine transform or other orthogonal transform and by motion compensation.

An encoding device of such a standard utilizes local information of the image so as to realize high efficiency encoding.

An image by nature is not readily discernable in deterioration of image quality by the naked eye even when a complex portion in the image is encoded by making the

quantization rougher than that for the other portions.

[0003]   Accordingly, a conventional encoding device

divides an image into a plurality of portions, detects a

degree of complexity of the image for each portion, roughly

5   quantizes complex portions of the image based on the

detection result, and finely quantizes portions which are

not complex so as to suppress the influence of

deterioration of the image quality and at the same time

reduce the amount of data.

10   The information of the degree of complexity of an

image is called "activity".

A conventional encoding device calculates the activity

of the image data to be quantized and generates a

quantization scale defining the quantization scale for each

15 picture based on the activity. Namely, it determines an

amount of bits assigned to a picture for each picture.

The encoded data generated by the encoding device is

stored in a buffer CPB (coded picture buffer) in a decoding

device, then the pictures composing the encoded data are

20 sequentially supplied to the decoding unit with a

predetermined picture rate for decoding.

Here, the amount of reduction of the amount of stored

data of the buffer CPB by the supply of one picture from

the buffer CPB to the decoding unit depends upon the amount

25 of data of the picture, that is, the quantization parameter

of the picture.

Accordingly, the encoding device must determine the quantization scale so that the buffer CPB of the decoding device does not underflow.

5   DISCLOSURE OF THE INVENTION

PROBLEM TO BE SOLVED BY THE INVENTION

[0004]   However, in the above conventional encoding device, the quantization scale of each picture is determined based on only the activity of the image data to

10   be quantized, therefore sometimes the amount of data of the picture finally encoded so as to suitably hold the state of the buffer CPB cannot be controlled and there is the problem that the quality of the decoded image is low.

[0005]   The present invention was made in consideration

15   with such a circumstance and has as an object thereof to provide a data processing apparatus able to generate encoded data able to give a high quality decoded image and a method and an encoding device of the same.

MEANS FOR SOLVING THE PROBLEM

20   [0006]   To solve the above problem of the prior art and achieve the above object, there is provided a data processing apparatus for determining a quantization scale of the quantization when quantizing and encoding processed data, comprising a specifying circuit for specifying a bit

25   rate by which the encoded data is supplied for decoding at

the time of the decoding based on the encoded data obtained

by the encoding; an encoding difficulty detection circuit

for detecting the difficulty of encoding of the processed

data; and a quantization control circuit for controlling

5   the quantization scale based on the bit rate specified by

the specifying circuit and the encoding difficulty detected

by the encoding difficulty detection circuit.

[0007]   The mode of operation of the data processing

apparatus of the first invention becomes as follows.

10   The specifying circuit specifies the bit rate by which

the related encoded data is supplied for decoding at the

time of decoding based on the encoded data obtained by the

encoding.

Further, the encoding difficulty detection circuit

15   detects the encoding difficulty of the processed data.

Further, the quantization control circuit controls the

quantization scale based on the bit rate specified by the

specifying circuit and the encoding difficulty detected by

the encoding difficulty detection circuit.

20   [0008]   The data processing method of a second aspect of

the invention is a data processing method for determining a

quantization scale of quantization when quantizing and

encoding processed data, comprising a first step of

specifying a bit rate by which the encoded data is supplied

25   for decoding at the time of the decoding based on the

encoded data obtained by the encoding; a second step of

detecting the encoding difficulty of the processed data;

and a third step of controlling the quantization scale

based on the bit rate specified at the first step and the

5   encoding difficulty detected at the second step.

[0009]   The mode of operation of the data processing

method of the second aspect of the invention becomes as

follows.

At the first step, the bit rate by which the encoded

10   data is supplied for decoding at the time of decoding is

specified based on the encoded data obtained by the

encoding.

Further, at the second step, the encoding difficulty

of the processed data is detected.

15   Further, at the third step, the quantization scale is

controlled based on the bit rate specified at the first

step and the encoding difficulty detected at the second

step.

[0010]   An encoding device of the third aspect of the

20   invention has a quantization scale calculation circuit for

calculating the quantization scale, a quantization circuit

for quantizing the processed data based on the quantization

scale calculated by the quantization scale calculation

circuit, and an encoding circuit for generating the encoded

25   data by encoding the quantization result of the

quantization circuit, the quantization scale calculation

circuit having a specifying circuit for specifying a bit

rate by which the encoded data is supplied for decoding at

the time of decoding based on encoded data generated by the

5   encoding circuit, an encoding difficulty detection circuit

for detecting an encoding difficulty of the processed data,

and a quantization control circuit for controlling the

quantization scale based on the bit rate specified by the

specifying circuit and the encoding difficulty detected by

10   the encoding difficulty detection circuit.

[0011]   The mode of operation of the encoding device of

the third aspect of the invention becomes as follows.

The quantization scale calculation circuit calculates

the quantization scale by a mode of operation similar to

15   that of the first aspect of the invention.

Next, the quantization circuit quantizes the processed

data based on the quantization scale calculated by the

quantization scale calculation circuit.

Next, the encoding circuit encodes the quantization

20   result of the quantization circuit to generates the encoded

data.

EFFECTS OF THE INVENTION

[0012]   According to the present invention, there can be

provided a data processing apparatus able to generate

25   encoded data able to give a high quality decoded image and

a method and an encoding device of the same.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013]   [FIG. 1] FIG. 1 is a view of the overall

configuration of an image processing system of an

embodiment of the present invention.

[FIG. 2] FIG. 2 is a view of the configuration of an

encoding device 2 shown in FIG. 1.

[FIG. 3] FIG. 3 is a view of the configuration of a Q

calculation circuit shown in FIG. 2 relating to a portion

generating a quantization scale MBQ based on encoded data

ED.

[FIG. 4] FIG. 4 is a flow chart for explaining

processing of an MBR measurement circuit shown in FIG. 3.

[FIG. 5] FIG. 5 is a diagram for explaining the

processing of an LT adjustment amount calculation circuit

shown in FIG. 3.

[FIG. 6] FIG. 6 is a diagram for explaining the

processing of the LT adjustment amount calculation circuit

shown in FIG. 3.

[FIG. 7] FIG. 7 is a flow chart for explaining the

processing of an ST adjustment amount calculation circuit

shown in FIG. 3.

[FIG. 8] FIG. 8 is a diagram showing a relationship

between data CpbScale and indicator data CPBOC.

[FIG. 9] FIG. 9 is a flow chart for explaining the

processing of a PicQ control circuit shown in FIG. 3.

[FIG. 10] FIG. 10 is a flow chart for explaining an overall operation of the Q calculation circuit shown in FIG. 3.

5   [FIG. 11] FIG. 11 is a flow chart for explaining the processing of step ST42 shown in FIG. 10.

DESCRIPTION OF NOTATIONS

[0014]   1... communication system, 2... encoding device, 3... decoding device, 4... decoding unit, 5... decoding

10   difficulty detection circuit, 6... image difficulty indicator generation circuit, 10... MBR measurement circuit, 11... a CPBOC calculation circuit, 12... LT adjustment amount calculation circuit, 13... ST adjustment amount calculation circuit, 14... CTBR calculation circuit, 15...

15   delay circuit, 16... PicQ control circuit, 17... MBQ control circuit, 22... A/D conversion circuit, 23... picture rearrangement circuit, 24... processing circuit, 25... orthogonal transform circuit, 26... quantization circuit, 27... reversible encoding circuit, 28... buffer,

20   29... inverse quantization circuit, 30... inverse orthogonal transform circuit, 31... frame memory, 32... motion prediction and/or compensation circuit, 33... activity calculation circuit, 34... Q calculation circuit, CPB... buffer

25   BEST MODE FOR WORKING THE INVENTION

[0015]   Below, an image processing apparatus according to an embodiment of the present invention will be explained.

Below, an image processing apparatus of the present embodiment for solving the above problem and a method and

5   an encoding device of the same will be explained.

FIG. 1 is a view of the overall configuration of an image processing system 1 of the present embodiment.

As shown in FIG. 1, the image processing system 1 has an encoding device 2 and a decoding device 3. The encoding

10   device 2 generates encoded data ED (bit stream) compressed by a discrete cosine transform, Karhunen Loeve transform, or other orthogonal transform and motion compensation, modulates the encoded data ED, then transmits the same via a satellite broadcast wave, cable TV network, telephone

15   line network, mobile phone line network, or other transmission medium.

The decoding device 3 for example demodulates the encoded data ED received from the encoding device 2, then stores the same in a buffer CPB, supplies the encoded data

20   ED read out from the buffer CPB (memory circuit of the present invention) to the decoding unit 4, generates the image data decoded by the inverse transform to the orthogonal transform at the time of the encoding and motion compensation in the decoding unit 4, and utilizes the same.

25   Here, the amount of the reduction of the amount of

data stored by the buffer CPB by the supply of one picture

from the buffer CPB to the decoding unit 4 depends upon the

amount of data of the picture, that is, the quantization

parameter of the picture.

5   Therefore, the encoding device has to determine the

quantization scale so that the buffer CPB of the decoding

device 3 will not overflow and underflow as will be

explained later.

Note that the transmission medium may be a storage

10 medium such as an optical disk, magnetic disk, and

semiconductor memory as well.

The image processing system 1 is characterized in the

method of calculation of the quantization scale in the

encoding device 2.

15 [0016]   Below, the encoding device 2 shown in FIG. 1 will

be explained.

The encoding device 2 corresponds to the encoding

device of the inventions.

FIG. 2 is a view of the configuration of the encoding

20 device 2 shown in FIG. 1.

As shown in FIG. 2, the encoding device 2 has for

example an A/D conversion circuit 22, a picture

rearrangement circuit 23, a processing circuit 24, an

orthogonal transform circuit 25, a quantization circuit 26,

25 a reversible encoding circuit 27, a buffer 28, an inverse

quantization circuit 29, an inverse orthogonal transform circuit 30, a frame memory 31, a Q calculation circuit 34, a motion prediction and/or compensation circuit 36, and a deblock filter 37.

5   [0017]   The quantization circuit 26 is an example of the quantization circuit of the third aspect of the invention, the reversible encoding circuit 27 is an example of the encoding circuit of the third aspect of the invention, and the Q calculation circuit 34 is an example of the data

10   processing apparatus of the first aspect of the invention and the quantization scale calculation circuit of the third aspect of the invention.

[0018]   Below, components of the encoding device 2 shown in FIG. 2 will be explained.

15   The A/D conversion circuit 22 converts an input analog image signal comprised of a luminance signal Y and color difference signals Pb and Pr to a digital image signal and outputs this to the picture rearrangement circuit 23.

The picture rearrangement circuit 23 outputs image

20   data S23 (processed data of the present invention) obtained by rearranging frame image signals in image signals input from the A/D conversion circuit 22 to a sequence of encoding in accordance with a GOP (Group Of Pictures) structure comprised by picture types I, P, and B thereof to

25   the processing circuit 24, the motion prediction and/or

compensation circuit 36, and the Q calculation circuit 34.

[0019]   When the image data S23 is inter-encoded, the processing circuit 24 generates image data S24 indicating the difference between the image data S23 and predicted

5   image data S32a input from the motion prediction and/or compensation circuit 36 and outputs this to the orthogonal transform circuit 25.

Further, when the image data S23 is intra-encoded, the processing circuit 24 outputs the image data S23 as the

10   image data S24 to the orthogonal transform circuit 25.

The orthogonal transform circuit 25 applies a discrete cosine transform or Karhunen Loeve transform or other orthogonal transform to the image data S24 to generate image data (for example DCT coefficient signal) S25 and

15   outputs this to the quantization circuit 26.

The quantization circuit 26 quantizes the image data S25 in units of macro blocks MB with the quantization scale MBQ input from the Q calculation circuit 34 to generate image data S26 and outputs this to the reversible encoding

20   circuit 27 and the inverse quantization circuit 29.

[0020]   The reversible encoding circuit 27 performs variable length encoding or arithmetic encoding on the image data S26 to generate the encoded data ED and stores this in the buffer 28.

25   At this time, the reversible encoding circuit 27

encodes the motion vector MV input from the motion

prediction and/or compensation circuit 36 or the difference

thereof and stores the same in header data of the encoded

data ED.

5   The encoded data ED stored in the buffer 28 is output

to the Q calculation circuit 34 and, at the same time, for

example modulated, then is transmitted to the decoding

device 3 shown in FIG. 1.

[0021]   The inverse quantization circuit 29 generates the

10   data by inverse quantizing the image data S26 and outputs

this to a display 40.

The inverse quantization circuit 29 performs the

quantization processing based on the JVT standard.

The inverse orthogonal transform circuit 30 applies an

15   inverse transform to the orthogonal transform described

above to the inverse quantized data input from the inverse

quantization circuit 29 to generate the image data and

outputs the same to the deblock filter 37.

The deblock filter 37 strips block distortion from the

20   image data input from the inverse quantization transform

circuit 30 and writes the data into the frame memory 31.

[0022]   The motion prediction and/or compensation circuit

36 performs the motion prediction and/or compensation

processing based on the image data S31 from the frame

25   memory 31 and the image data S23 from the picture

rearrangement circuit 23 to calculate the motion vector MV

and the predicted image data S32a.

Note that the motion prediction and/or compensation

circuit 36 determines a macro block type based on the

5   quantization scale MBQ of the macro block MB from the Q

calculation circuit 34 and performs the motion prediction

and/or compensation processing using the block prescribed

by the determined macro block type as the units.

The motion prediction and/or compensation circuit 36

10   outputs the motion vector MV to the reversible encoding

circuit 27 and outputs the predicted image data S32a to the

processing circuit 24.

[0023]   The Q calculation circuit 34 calculates the

quantization scale PicQ of each picture based on the image

15   data S23 from the picture rearrangement circuit 23 and the

encoded data ED from the buffer 28.

Specifically, the Q calculation circuit 34 calculates

the quantization scale MBQ of each macro block MB composing

each picture based on the calculated quantization scale

20   PicQ and outputs this to the quantization circuit 26 and

the motion prediction and/or compensation circuit 36.

Below, the method of calculating the quantization

scale PicQ based on the image data S23 and the encoded data

ED will be explained.

25   The Q calculation circuit 34 controls the quantization

scale PicQ of each picture, that is, the amount of data of each picture, so that the amount of data of the encoded data ED stored in the buffer CPB approaches a suitable value (initial value InitialCpb) while considering the

5   state of the buffer CPB of the decoding device 3 shown in FIG. 1 other than the encoding difficulty of the image data S23.

Here, the number of pictures read out from the buffer CPB in the unit time and supplied to the decoding unit 4 is

10   a constant number prescribed by the picture rate, therefore, by controlling the amount of data of each picture by the Q calculation circuit 34, the amount of data (amount stored in buffer accumulation) of the encoded data ED stored in the buffer CPB can be controlled.

15   [0024]   Below, the configuration of the Q calculation circuit 34 shown in FIG. 2 will be explained in detail.

FIG. 3 is a view of the configuration of the Q calculation circuit 34 shown in FIG. 2 relating to the portion for generating the quantization scale MBQ based on

20   the encoded data ED.

As shown in FIG. 3, the Q calculation circuit 34 has for example an encoding difficulty detection circuit 5, an image difficulty indicator generation circuit 6, a generated bit amount detection circuit 8, an MBR

25   measurement circuit 9, an ABR measurement circuit 10, a

CPBOC calculation circuit 11, an LT adjustment amount

calculation circuit 12, an ST adjustment amount calculation

circuit 13, a CTBR calculation circuit 14, a delay circuit

15, a PicQ control circuit 16, and an MBQ control circuit

5   17.

In FIG. 3, the MBR measurement circuit 9 corresponds

to the specifying circuit of the first and third aspects of

the invention, the encoding difficulty detection circuit 5

and the image difficulty indicator generation circuit 6

10   correspond to the encoding difficulty detection circuit of

the first and third aspects of the invention, and the PicQ

control circuit 16 corresponds to the quantization control

circuit of the first and third aspects of the invention.

Further, the CPBOC calculation circuit 11 corresponds

15   to the indicator generation circuit of the first aspect of

the invention, and the LT adjustment amount calculation

circuit 12, the ST adjustment amount calculation circuit 13,

and the CTBR calculation circuit 14 correspond to the

target calculation circuit of the first aspect of the

20   invention.

[0025]   [Encoding Difficulty Detection Circuit 5]

The encoding difficulty detection circuit 5 detects

the encoding difficulty of the image data S23 input from

the picture rearrangement circuit 23 and outputs encoding

25   difficulty data E_DIFCTED indicating the detected encoding

difficulty to the image difficulty indicator generation circuit 6.

The encoding difficulty detection circuit 5 specifically generates the encoding difficulty data

5   E_DIFCTED so that the value becomes larger as a larger number of image patterns are included based on the image pattern which becomes a factor generating block noise or mosquito noise included in the frame of the image data S23, for example, vigorous motion and vigorous luminance changes

10   (or scene change) in fine picture patterns.

[0026]   [Image Difficulty Indicator Generation Circuit 6]

The image difficulty indicator generation circuit 6 multiplies the predetermined difficulty coefficient, the designated final target bit rate FTBR, and the encoding

15   difficulty data E_DIFCT input from the encoding difficulty detection circuit 5 as shown in the following Equation (1) to generate the image difficulty indicator data DIFCT.

The image difficulty indicator generation circuit 6 outputs the generated image difficulty indicator data DIFCT

20   to the CTBR calculation circuit 14.

[0027]   (Equation 1)

DIFCT = (Difficulty coefficient)*FTBR*E_DIFCT

$$\ldots (1)$$

Note that the image difficulty indicator generation

25   circuit 6 calculates the image difficulty indicator data

DIFCT using for example a constant time, several pictures, or several GOP's as units.

In the present embodiment, by treating the image difficulty indicator data DIFCT as a relative indicator from the overall sequence, it is possible to realize a variable bit rate of multi-paths and possible to realize a variable bit rate of a single path by using it for a portion of the sequence.

[0028]   [Generated Bit Amount Detection Circuit 8]

The generated bit amount detection circuit 8 detects the amount of bits (amount of generated bits) of the encoded data ED (bit stream) input from the buffer 28 shown in FIG. 2 and outputs bit amount data BA indicating the result to the MBR measurement circuit 9, the ABR measurement circuit 10, and the CPBOC calculation circuit 11.

[0029]   [MBR Measurement Circuit 9]

The MBR measurement circuit 9 calculates the measurement bit rate CMBR (bit rate specified by the specifying circuit of the present embodiment) indicating the bit rate of each picture composing the encoded data ED based on the bit amount data BA input from the generated bit amount detection circuit 8 and outputs this to the PicQ control circuit 16.

[0030]   The measurement bit rate CMBR indicates the bit

rate by which the encoded data ED is read out from the
buffer CPB and output to the decoding unit 4 in the
decoding device 3 shown in FIG. 1.

FIG. 4 is a flow chart for explaining the processing

5   of the MBR measurement circuit 9.

Step ST1:

The MBR measurement circuit 9 calculates an average
bit amount AveIPicBit of I pictures composing the encoded
data ED encoded in the past based on the bit amount data BA

10 input from the generated bit amount detection circuit 8.

Step ST2:

The MBR measurement circuit 9 calculates the average
bit amount AvePPicBit of P pictures composing the encoded
data ED encoded in the past.

15   Step ST3:

The MBR measurement circuit 9 calculates the
measurement bit rate CMBR by the following Equation (2)
based on AveIPicBit calculated at step ST1 and the
AvePPicBit calculated at step ST2.

20 [0031]   (Equation 2)

CMBR = PicR*(AveIPicBit+AvePPicBit*PPicNumInGop)/
TotalPicNumInGop   … (2)

[0032]   In the above Equation (2), TotalPicNumInGop is a
constant indicating the number of pictures in one GOP and

25 is set previously.

Further, PPicNumInGop indicates (TotalPicNumInGop-1)

[0033]   [ABR Measurement Circuit 10]

The ABR measurement circuit 10 calculates the

cumulative amount of bits (amount of data) composing the

5   encoded data ED based on the bit amount data BA input from

the generated bit amount detection circuit 8 and calculates

the average bit rate ABR based on this.

Specifically, the ABR measurement circuit 10

calculates the average bit rate ABR based on the cumulative

10   value of the bit amount data BA obtained after starting the

encoding of the content of the encoding target in the

encoding device 2.

The ABR measurement circuit 10 outputs the above

calculated average bit rate ABR to the LT adjustment amount

15   calculation circuit 12.

[0034]   [CPBOC Calculation Circuit 11]

The CPBOC calculation circuit 11 calculates the

indicator data CPBOC indicating the amount of data (amount

of stored data) of the encoded data ED stored in the buffer

20   CPB of the decoding device 3 based on the bit amount data

BA input from the generated bit amount detection circuit 8.

The CPBOC calculation circuit 11 outputs the indicator

data CPBOC to the LT adjustment amount calculation circuit

12 and the ST adjustment amount calculation circuit 13.

25   [0035]   [LT Adjustment Amount Calculation Circuit 12]

The LT adjustment amount calculation circuit 12 calculates the adjustment amount LTAJ for adjusting the target bit rate CTBR so that the measurement bit rate CMBR approaches the final target bit rate FTBR.

5   The LT adjustment amount calculation circuit 12 calculates the adjustment amount LTAJ of the target bit rate CTBR explained later based on the indicator data CPBOC from the CPBOC calculation circuit 11 and the average bit rate ABR from the ABR measurement circuit 10.

10   Here, the adjustment amount LTAJ is for adjustment so as to prevent the target bit rate CTBR from becoming negative.

The LT adjustment amount calculation circuit 12 calculates the adjustment amount LTAJ of the target bit
15   rate CTBR by the following Equation (3) based on the final target bit rate FTBR (final target bit rate of the present invention) designated from the outside of the encoding device 2, the average bit rate ABR input from the ABR measurement circuit 10, an encoding elapsed time ELAPSED,
20   and a correction period DURATION.

[0036]   Here, the encoding elapsed time ELAPSED indicates a time from when the encoding of the content as the encoding target is started at the encoding device 2 to when the frame in the content is next encoded.

25   Further, the correction period DURATION is the period

during which for example the target bit rate CTBR is
updated.

The LT adjustment amount calculation circuit 12
calculates the adjustment amount LTAJ so that the final
target bit rate FTBR is obtained after the elapse of the
correction period DURATION for the average bit rate ABR at
the timing of the encoding elapsed time ELAPSED.

[0037]   (Equation 3)

$$LTAJ = (FTBR-ABR)*(ELAPSED+DURATION)/DURATION$$

$$\ldots (3)$$

[0038]   Note that, in order to suppress the influence of
the unstable average bit rate ABR immediately after the
start of the encoding, the LT adjustment amount calculation
circuit 12 may calculate the adjustment amount LTAJ of the
target bit rate CTBR as shown in the following Equation (4)
as well.

In the following Equation (4), the initial value
InitialLTDelay is a constant value defined for suppressing
the influence of the initial fluctuation of the adjustment
amount LTAJ and is for example 5 (sec).

[0039]   (Equation 4)

$$LTAJ = min(1.0, ELAPSED/initialLTDelay)*LTAJ$$

$$\ldots (4)$$

[0040]   The LT adjustment amount calculation circuit 12
calculates the adjustment amount LTAJ so that it becomes

the adjustment amount LTAJ calculated in the above Equation

(3) or less while the encoding elapsed time ELAPSED is the

initial value initialLTDelay, while makes it approach the

adjustment amount LTAJ calculated in the above Equation (3)

5   along with the encoding elapsed time ELAPSED approaching

the initial value initialLTDelay.

[0041]   The adjustment amount LTAJ has a value indicating

a positive value when the indicator data CPBOC is the

initial value initialCpb or more, that is, making

10   adjustment in a direction raising the target bit rate CTBR.

Further, the adjustment amount LTAJ has a value

indicating a negative value when the indicator data CPBOC

is less than the initial value initialCpb, that is, making

adjustment in a direction lowering the target bit rate CTBR.

15   Further, the adjustment amount LTAJ is defined so as

not to become smaller than a predetermined value even when

the indicator data CPBOC becomes the predetermined value or

less. By this, the target bit rate CTBR becoming negative

is avoided.

20   The characteristic feature of the adjustment amount

LTAJ explained above is obtained by the LT adjustment

amount calculation circuit 12 calculating the adjustment

amount LTAJ of the target bit rate CTBR by the above

Equations (3) and (4).

25   Note that the LT adjustment amount calculation circuit

12 calculates the adjustment amount LTAJ for example for a

constant time using several pictures or several GOP's as

units.

[0042]   [ST Adjustment Amount Calculation Circuit 13]

5   The ST adjustment amount calculation circuit 13

calculates the adjustment amount STAJ for adjusting the

target bit rate CTBR so that the buffer CPB of the decoding

device 3 does not underflow.

The ST adjustment amount calculation circuit 13

10   calculates the adjustment amount STAJ of the target bit

rate CTBR based on the indicator data CPBOC from the CPBOC

calculation circuit 11.

Here, the adjustment amount STAJ acts to return the

indicator data CPBOC to the initial value initialCpb.

15   FIG. 7 is a flow chart for explaining the processing

of the ST adjustment amount calculation circuit 13.

Step ST21:

The ST adjustment amount calculation circuit 13

calculates data CpbScale by the following Equation (5) by

20   using the indicator data CPBOC input from the CPBOC

calculation circuit 11.

[0043]   (Equation 5)

$$CpbScale = ((Scale*(InitCpb-CPBOC)+CPBOC)/((InitCpb-CPBOC)+Scale*(CPBOC))$$

25   … (5)

[0044]   FIG. 8 is a diagram showing a relationship

between the data CpbSclae and the indicator data CPBOC.

As shown in FIG. 8, the data CpbScale has a value

indicating a predetermined positive value K when the

5   indicator data CPBOC is the initial value initialCpb or

more, that is, making an adjustment in a direction raising

the target bit rate CTBR.

Further, the data CpbScale has a value indicating a

negative value when the indicator data CPBOC is less than

10   the initial value initialCpb, that is, making an adjustment

in a direction lowering the target bit rate CTBR.

Further, as shown in FIG. 8, the data CpbScale

abruptly becomes small in value when the indicator data

CPBOC becomes the predetermined value (for example 180000)

15   or less.

Due to this, underflow of the buffer CPB of the

decoding device explained above is avoided.

The characterizing feature of the data CpbScale

explained above is realized by the ST adjustment amount

20   calculation circuit 13 calculating the data CpbScale by the

above Equation (5).

[0045]   Step ST22:

The ST adjustment amount calculation circuit 13

multiplies the data CpbScale and the input final target bit

25   rate FTBR by the following Equation (6) to calculate the

adjustment amount STAJ.

[0046]   (Equation 6)

    STAJ = FTBR*CpbScale   ... (6)

[0047]   [CTBR Calculation Circuit 14]

5   The CTBR calculation circuit 14 adds the input final

target bit rate FTBR, the image difficulty indicator data

DIFCT input from the image difficulty indicator generation

circuit 6, the adjustment amount LTAJ input from the LT

adjustment amount calculation circuit 12, and the

10   adjustment amount STAJ input from the ST adjustment amount

calculation circuit 13 by the following Equation (7) to

calculate the target bit rate CTBR.

    The CTBR calculation circuit 14 outputs the target bit

rate CTBR to the PicQ control circuit 16.

15   [0048]   (Equation 7)

    CTBR = FTBR+DIFCT+LTAJ+STAJ   ... (7)

[0049]   [Delay Circuit 15]

    The delay circuit 15 delays the Q scale QPic of the

picture input from the PicQ control circuit 16 by exactly a

20   time corresponding to 1 picture and outputs the result to

the PicQ control circuit 16.

[0050]   [PicQ Control Circuit 16]

    The PicQ control circuit 16 calculates (determines)

the Q scale QPic (quantization scale of the present

25   invention) of the picture Q and outputs this to the delay

circuit 15 and the MBQ control circuit 17.

The PicQ control circuit 16 calculates the Q scale

QPic as follows based on the measurement bit rate CMBR

input from the MBR measurement circuit 9 and the target bit

5   rate CTBR input from the CTBR calculation circuit 14.

Specifically, the PicQ control circuit 16 calculates

the Q scale QPic so as to make the measurement bit rate

CMBR approach the target bit rate CTBR.

[0051]   FIG. 9 is a flow chart for explaining the

10   processing of the PicQ control circuit 16.

Step ST31:

The PicQ control circuit 16 calculates the data

PRO_PART by the following Equation (8) by using the

measurement bit rate CMBR input from the MBR measurement

15   circuit 9 and the target bit rate CTBR input from the CTBR

calculation circuit 14.

Kp in Equation (8) is a coefficient for adjusting the

response and is defined by using for example the

measurement bit rate CMBR, the target bit rate CTBR, and

20   the indicator data CPBOC.

By making the response low, the fluctuation of the

quantization scale can be suppressed.

[0052]   (Equation 8)

PRO_PART = Kp*(CMBR/CTBR-1)   ... (8)

25   [0053]   Step ST32:

The PicQ control circuit 16 calculates the data

DV_PART by the following Equation (9) by using the

measurement bit rate CMBR input from the MBR measurement

circuit 9 and the target bit rate CTBR input from the CTBR

5   calculation circuit 14.

Kd in Equation (9) is a coefficient for improving the

response.

Further, n indicates the number of pictures. CMBR[n-1]

indicates the CMBR of one previous picture of the picture

10 corresponding to CMBR[n].

[0054]   (Equation 9)

$$DV\_PART = Kd*(CMBR[n]-CMBR[n-1])$$

$$\dots (9)$$

[0055]   Step ST33:

15 The PicQ control circuit 16 calculates the

quantization scale QPic[n] by the following Equation 10 by

using the quantization scale QPic[n-1] calculated the

previous time, the data PRO_PART calculated at step ST31,

and the data DV_PART calculated at step ST32.

20 [0056]   (Equation 10)

$$QPic[n] = QPic[n-1]*(1+PRO\_PART+DV\_PART)$$

$$\dots (10)$$

[0057]   [MBQ Control Circuit 17]

The MBQ control circuit 17 calculates the quantization

25 scale MBQ of each macro block MB in the picture based on

the quantization scale PicQ of the picture input from the

PicQ control circuit 16 and outputs this to the

quantization circuit 26 and motion prediction and/or

compensation circuit 36 shown in FIG. 2.

5 [0058]   Below, the overall operation of the Q calculation

circuit 34 shown in FIG. 3 will be explained.

FIG. 10 is a flow chart for explaining the overall

operation of the Q calculation circuit 34 shown in FIG. 3.

Step ST41:

10   The MBR measurement circuit 9 of the Q calculation

circuit 34 shown in FIG. 3 calculates the measurement bit

rate CMBR in a sequence explained by using FIG. 4.

Step ST42:

The CPBOC calculation circuit 11, the LT adjustment

15 amount calculation circuit 12, the ST adjustment amount

calculation circuit 13, and the CTBR calculation circuit 14

shown in FIG. 3 calculate the target bit rate CTBR in the

sequence explained by using FIG. 5 to FIG. 8.

Namely, as shown in FIG. 11, the LT adjustment amount

20 calculation circuit 12 calculates the adjustment amount

LTAJ (ST51) in the sequence explained before by using FIG.

5 and FIG. 6, the ST adjustment amount calculation circuit

13 calculates the adjustment amount STAJ (ST52) in the

sequence explained before by using FIG. 7 and FIG. 8, and

25 the CTBR calculation circuit 14 calculates the target bit

rate CTBR (ST53) by using this.

[0059]   Step ST43:

The PicQ control circuit 16 of the Q calculation

circuit 34 calculates the quantization scale QPic of each

5 picture based on the measurement bit rate CMBR calculated

at step ST41 and the target bit rate CTBR calculated at

step ST42 as explained by using FIG. 9, then calculates the

quantization scale MBQ of each macro block MB and outputs

this to the quantization circuit 26 and the motion

10 prediction and/or compensation circuit 36.

[0060]   Next, the overall operation of the encoding

device 2 shown in FIG. 2 will be explained.

The image signal which becomes the input is first

converted to a digital signal at the A/D conversion circuit

15 22. Next, in accordance with the GOP structure of the image

compressed information which becomes the output, the image

data is rearranged in the picture rearrangement circuit 23.

The Q calculation circuit 34 calculates the

quantization scale MBQ based on the image data S23 from the

20 picture rearrangement circuit 23 and the encoded data ED

from the buffer 28 as previously explained and outputs this

to the quantization circuit 26 and the motion prediction

and/or compensation circuit 36.

[0061]   For image data to be subjected to intra-encoding,

25 the image information of the overall image data is input to

the orthogonal transform circuit 25. The orthogonal

transform circuit 25 applies a discrete cosine transform,

Karhunen Loeve transform, or other orthogonal transform.

The transform coefficient output from the orthogonal

5   transform circuit 25 is subjected to quantization

processing at the quantization circuit 26 and output as the

image data S25 to the reversible encoding circuit 27.

The quantization circuit 26 quantizes the image data

S25 based on the quantization scale QP based on the

10   quantization scale MBQ input from the Q calculation circuit

34.

The reversible encoding circuit 27 applies reversible

encoding such as variable length encoding or arithmetic

encoding to the image data S26 to generate the encoded data

15   ED and outputs this to the buffer 28.

Simultaneously, the image data S26 from the

quantization circuit 26 is input to the inverse

quantization circuit 29 and further subjected to the

inverse orthogonal transform processing at the inverse

20   orthogonal transform circuit 30 to become the decoded image

data. The image data is stored in the frame memory 31.

[0062]   On the other hand, for an image to be subjected

to inter-encoding, first, the image data S23 is input to

the motion prediction and/or compensation circuit 36.

25   Further, the image data S31 of the reference image is read

out from the frame memory 31 and output to the motion

prediction and/or compensation circuit 36.

Then, the motion prediction and/or compensation

circuit 36 generates the motion vector MV and the predicted

5   image data S32a by using the image data S31 of the

reference image.

[0063]   Then, the processing circuit 24 generates the

image data S24 as a difference signal between the image

data S23 from the picture rearrangement circuit 23 and the

10   predicted image data S32a from the motion prediction and/or

compensation circuit 36 and outputs the image data S24 to

the orthogonal transform circuit 25.

Then, the reversible encoding circuit 27 performs

reversible encoding processing such as variable length

15   encoding or arithmetic processing on the motion vector MV

and inserts the result into the header portion of the image

data. The rest of the processing is the same as the image

data to be subjected to the intra-encoding.

[0064]   As explained above, the encoding device 2

20   determines the quantization scale MBQ by considering the

amount of stored data of the buffer CPB of the decoding

device 3 shown in FIG. 1 based on the encoded data ED from

the buffer 28 in the Q calculation circuit 34.

For this reason, according to the encoding device 2,

25   underflow of the buffer CPB of the decoding device 3 can be

avoided, and the quality of the image decoded at the

decoding unit 4 can be improved.

Further, the encoding device 2 determines the

quantization scale MBQ based on the image difficulty

5   indicator data DIFCT generated by the image difficulty

indicator generation circuit 6 in the Q calculation circuit

34.

For this reason, the Q calculation circuit 34 can use

many bits by making the quantization scale MBQ of the frame

10   (picture) having a high difficulty of encoding small and

can make the bit rate of the encoded data ED follow the

encoding difficulty of the image data S23 being encoded and

can provide a high quality image.

[0065]   Further, according to the encoding device 2, as

15   explained by using FIG. 4, the MBR measurement circuit 9

calculates the measurement bit rate CMBR based on the

average amount of bits of a plurality of pictures and

calculates the target bit rate CTBR based on this. For

this reason, large fluctuation of the quantization scale

20   MBQ of each picture due to the difference of the amounts of

bits of pictures can be avoided.

Further, according to the encoding device 2, the

processing load of the decoding unit 4 can be made uniform.

Due to this, the image quality after the decoding can be

25   improved.

Further, according to the encoding device 2, as shown

in the above Equation (9), the PicQ control circuit 16

calculates the quantization scale QPic by feedback. By this

as well, abrupt fluctuation in time of the quantization

5   scale QPic can be suppressed.

Further, according to the encoding device 2, by

adjusting the Kp in the above Equation (8), abrupt

fluctuation of the quantization scale can be suppressed. By

this as well, the processing load of the decoding unit 4

10 can be made uniform. Due to this, the image quality after

the decoding can be improved.

[0066]   Further, according to the encoding device 2, in

the encoding difficulty detection circuit 5, by switching

between whether the encoding difficulty is to be detected

15 for the entire sequence or the encoding difficulty is to be

detected for a portion of the sequence, variable bit rate

control suitable for both multi-paths and a single path can

be realized.

[0067]   The present invention is not limited to the above

20 embodiment.

Namely, a person skilled in the art may make a variety

of changes, combinations, sub combinations, and

substitutions concerning the components of the above

embodiment within the technical scope of the present

25 invention or a scope of equivalents thereof.

For example, the Q calculation circuit 34 shown in FIG.
3 may calculate the target bit rate CTBR based on only the
final target bit rate FTBR and the image difficulty
indicator data DIFCT from the image difficulty indicator
5   generation circuit 6 in the CTBR calculation circuit 14.

Further, the CTBR calculation circuit 14 may calculate
the target bit rate CTBR based on either of the adjustment
amount STAJ or LTAJ, the indicator final target bit rate
FTBR, and the image difficulty indicator data DIFCT.

10   INDUSTRIAL CAPABILITY

[0068]   The present invention can be applied to a system
quantizing processed data.